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Laparoscopic management of benign liver diseases: where are we?

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Background

The role of laparoscopic surgery in the management of benign cystic and solid liver tumours appears to differ according to each tumour type. As regards congenital liver cysts, laparoscopic treatment is now the gold standard for treating selected, huge, accessible, highly symptomatic or complicated cysts. In contrast, the laparoscopic approach is not useful for patients suffering from adult polycystic liver disease (PLD), except for type I PLD with large multiple hepatic cysts. For benign hepatocellular tumours, the surgical management has recently benefited from a better knowledge of the natural history of each type of tumour and from the improvement of imaging techniques in assuring a precise diagnosis of tumour nature. Thus the general tendency has led to a progressive restriction and tailoring of indications for resection in benign liver tumours, selecting only patients with huge, specifically symptomatic or compressive benign tumours or patients suffering from liver cell adenoma. Despite the enthusiastic use of the laparoscopic approach, selective indications for resection of benign liver tumours should indeed remain unchanged. For all types of benign liver tumours, the best indication remains small, superficial lesions, located in the anterior or the lateral segments of the liver. Deep, centrally located lesions or tumours in contact with major vascular or biliary trunks are not ideal candidates for laparoscopic liver resections. When performed by expert liver and laparoscopic surgeons using an adequate surgical technique, the laparoscopic approach is safe for performing minor liver resections and is accompanied by the usual postoperative benefits of laparoscopic surgery. When applied in selected patients and tumours, laparoscopic management of benign liver diseases appears to be a promising technique for hepatobiliary surgeons.

Keywords

laparoscopy, hepatectomy, liver resection, benign tumour, liver tumour, liver cyst, adult polycystic disease, hepatocellular tumour, liver cystadenoma

Introduction

A laparoscopic approach may be used for various types of cystic or solid benign liver lesions (Table 1). However, the role of laparoscopic surgery in the management of these conditions is different for each type of disease. Indeed, several key questions must be addressed to evaluate the role of minimally invasive surgery in the treatment of these diseases. First of all, is laparoscopic surgery able to achieve the main goal of treatment for each type of disease? Secondly, is it possible to treat laparoscopically all patients suffering from the disease? Or on the contrary, is a patient selection process necessary? Thirdly, is it possible to reproduce laparoscopically the same surgical procedure as the one successfully used during open surgery? Finally, should the laparoscopic approach achieve at least similar results to those offered by an open approach? Recent advances in the management of these conditions include a more clear classification of hepatocellular tumours, a better understanding of the natural history of each tumour type and improvements in modern imaging techniques in assuring a precise diagnosis of tumour nature. Thus the general tendency has led to a progressive restriction and tailoring of indications for surgical treatment in benign liver tumours, selecting only patients with huge, specifically symptomatic or compressive benign tumours or patients suffering from hepatocellular tumours associated with a complicated natural history. It should thus be strongly emphasised that despite the enthusiastic use of the laparoscopic approach, selective indications for surgical treatment of benign liver tumours should remain unchanged. The purpose of this review is to critically analyse the place of laparoscopic surgery in the manage-

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Table 1. *Types of liver diseases potentially amenable to a laparoscopic approach*

Cystic liver lesions	Congenital liver cyst
	Adult polycystic liver disease
	Hydatid liver cyst
	Liver cystadenoma
Solid liver lesions	Haemangioma
	Focal nodular hyperplasia
	Liver cell adenoma

ment of benign cystic and solid liver lesions, in the light of the general philosophy of treatment.

Cystic liver diseases

Laparoscopic surgery has been used for treating congenital liver cysts (CLC), adult polycystic liver disease (APLD), neoplastic liver cysts, such as liver cystadenoma, and hydatid liver cysts. The problem of hydatid liver cysts (HLC) will be analysed by another author in this issue of the journal.

Differential diagnosis

Above all, accurate differentiation between these different cystic hepatic lesions by imaging techniques and specific serological markers is essential, because treatment options vary from fenestration techniques for symptomatic CLC to radical liver resection for liver cystadenoma or to additional local parasitic inactivation for HLC. Despite the improvements in serological and imaging techniques, the parasitic nature of a hepatic cyst still may be misdiagnosed, as has already been reported [1, 2]. Indeed, young, unilocular echinococcal liver cyst, with pure intracystic fluid (named type I in the ultrasound Gharbi classification) [3] may simulate a simple CLC (Figure 1). Confusion is also possible between a congenital and a neoplastic liver cyst, leading to inappropriate treatment exposing the patient to tumour recurrence and reoperation [1, 4]. Indeed, in case of complicated CLC, i.e. by haemorrhage or superinfection, the radiological differentiation between benign CLC and neoplastic cyst may be difficult [5–7]. Thus, great attention should still be paid during laparoscopic treatment of such lesions to the appearance of unusual cystic fluid and to careful inspection of the inner aspect of cyst wall. Irregular and nodular aspects of the internal cystic walls should alert the surgeon to carry out multiple biopsies and frozen section examinations to rule out a neoplastic liver cyst [5, 8–11] (Figure 2).

Congenital liver cysts

Selection of patients. Because the natural history of CLC (even with large cysts) is silent in most patients, it should be highlighted that most of these do not require any treatment. Indeed, only 10–16% of these lesions will become symptomatic, i.e. painful or complicated with bleeding, superinfection or compression of adjacent structures. The purpose of treatment for CLC is to achieve complete and definitive decompression of the symptomatic liver cysts, leading to disappearance of the patient's symptoms.

The selection of patients for surgical treatment – including a laparoscopic approach – should thus concern only huge liver cysts (except if strategically situated) that are responsible for severe and specific cyst-related symp-

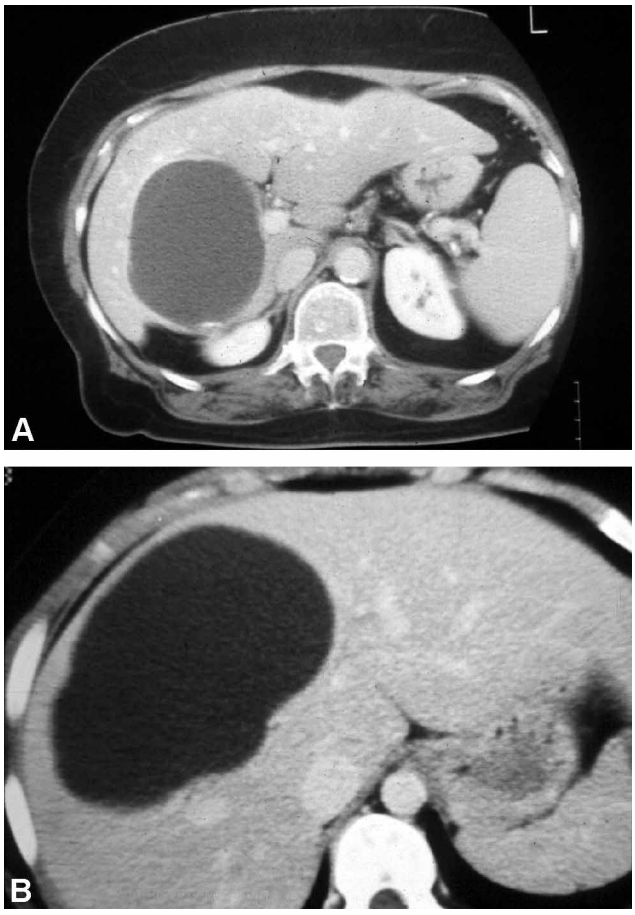

Figure 1. *Similar appearance on computed tomographic examination of a liver cystadenoma (A) and a hydatid liver cyst (B).*

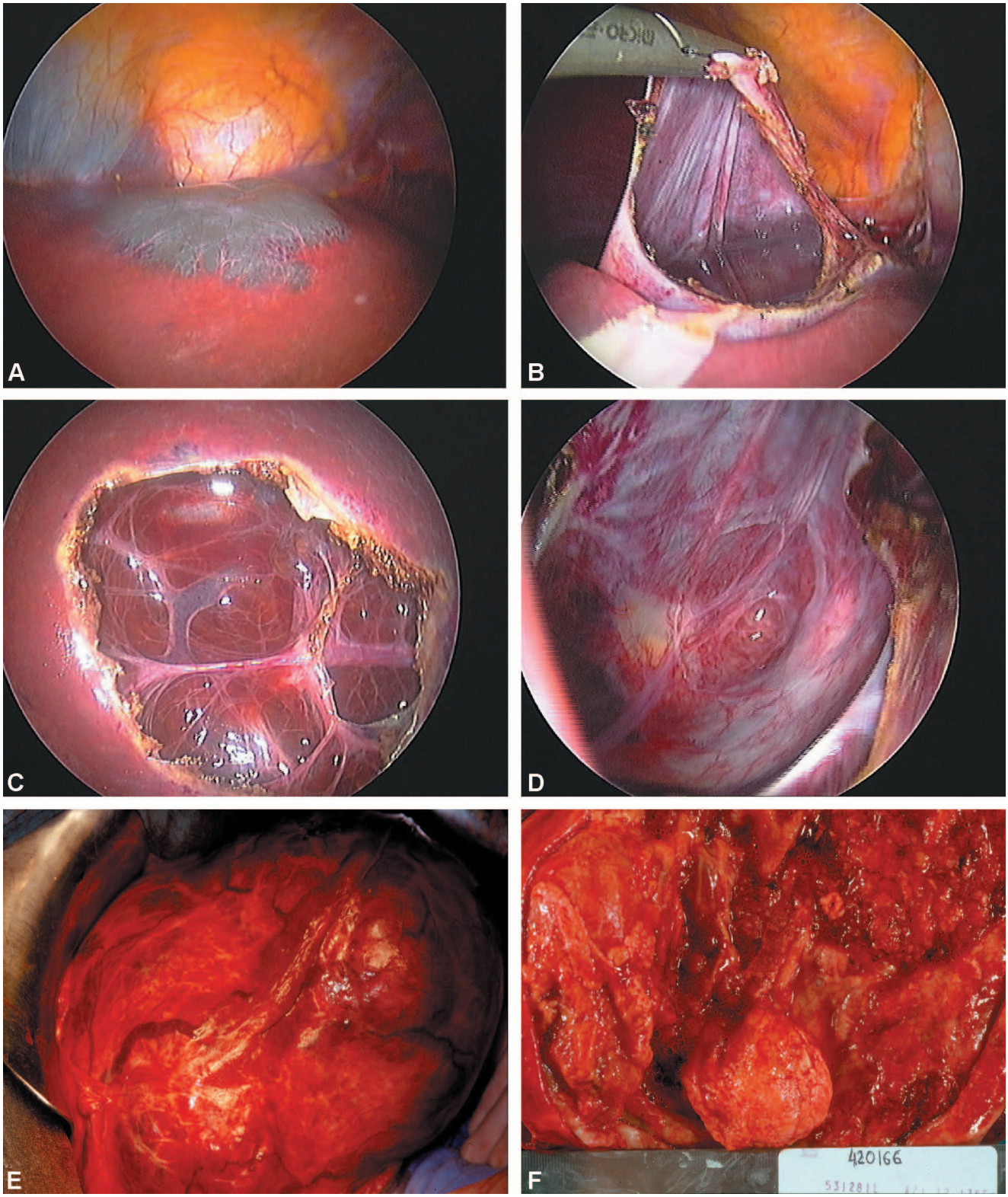

Figure 2. *External and internal macroscopic aspect of a typical congenital liver cyst (A–D) and a liver cystadenocarcinoma (E, F).*

Figure 3. *Poor indications for laparoscopic management of congenital liver cysts (CLC) include small, deeply, centrally or posteriorly located or multilocular liver cysts (left column). Good indications are huge, superficial CLC, apparent at the liver surface and located in Couinaud segments SII to SVI, or posteriorly if bulging (right column).*

toms or are complicated [12, 13]. Indeed, the causal relationship between abdominal pain and the presence of a large liver cyst must be always questioned before surgery and accepted only if the cyst is large enough or complicated and if other possible causes have been excluded. Not paying attention to this feature has been

proved to give poor long-term results in a multicentre series previously reported by us [8]. In case of doubt concerning the specificity of cyst-related abdominal pain, a percutaneous aspiration procedure should be employed as a pre-therapeutic test to determine if abdominal pain is specifically related to the cyst [8, 13]. If abdominal complaints resolve after percutaneous aspiration (and recur with cyst recurrence), symptoms can be reasonably attributed to the CLC. In this setting, good long-term results can then be expected, as reported in our experience [13]. If symptoms are not relieved after aspiration, the search for another cause of the symptoms should be continued and surgery must be avoided [8, 14]. On the other hand, percutaneous radiologically guided aspiration of hepatic cysts also helps to exclude other entities such as neoplastic cysts and liver abscess [14, 15].

Laparoscopic management of CLCs has been increasingly reported, but not all CLCs are amenable to laparoscopic treatment (Figure 3) [8, 12]. Again, a strict selection of patients is mandatory, the best candidates for a laparoscopic approach being large, superficial, accessible cysts at the liver surface (the cyst appearance should be carefully inspected on preoperative computed tomography), located in the anterior segments of the right liver or in the left lateral liver segments (segments II to VI in the Couinaud classification) [16]. Deeply sited and posterior liver cysts are difficult to reach during laparoscopic exploration [8, 12] (Figure 3). These patients may be good candidates for percutaneous alcohol sclerotherapy or for an open surgical approach [13]. Finally, CLCs located in segment VIII are more prone to early cyst recurrence after laparoscopic deroofing because the residual cyst cavity is immediately covered by the diaphragm, except in our experience if in situ omentoplasty is employed to obliterate the cystic cavity (Figure 4) [13].

Surgical technique. The importance of an appropriate and meticulous technique during laparoscopic treatment should be also emphasised. Wide fenestration technique (the so-called Lin procedure) [17] by deroofing the cyst wall using electrocautery or preferably harmonic shears is a key factor to avoid cyst recurrence, but great care should be taken to stay 1 cm away from the parenchymal liver edge in order to avoid bleeding from liver parenchyma. Additionally, the surgeon should pay great attention to careful inspection of the fenestrated cyst wall for possible bile leakage during the procedure. In this case, selective suture or clipping is mandatory if postoperative biliary fistula is to be avoided, as was the case in one of our patients, successfully treated by endoscopic sphinc-

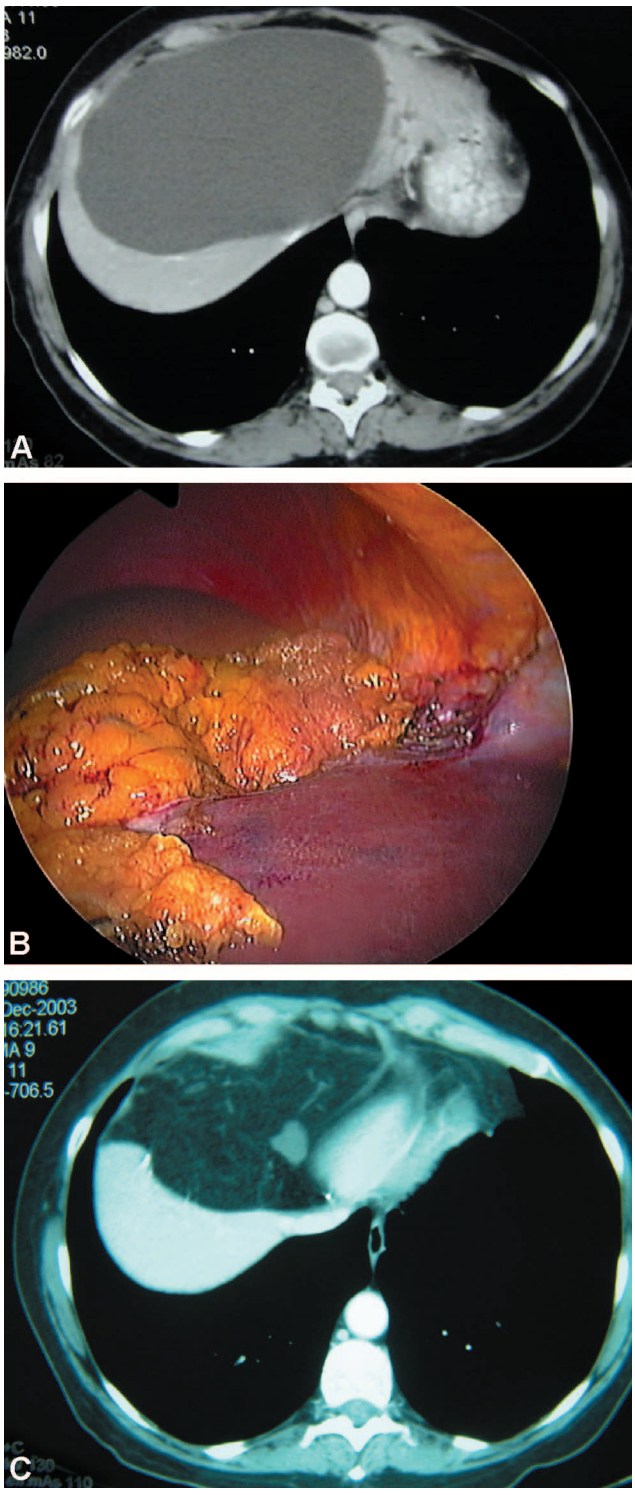

Figure 4. *Preoperative (A), peroperative (B) and postoperative (C) computed tomographic examinations of a huge symptomatic congenital liver cyst located in segment VIII, treated by laparoscopic fenestration and in situ omentoplasty (arrow).*

terotomy and stenting [13]. Finally, in our experience, ablating the cyst lining epithelium of the residual cystic cavity by the use of an argon beam coagulator is an important factor to avoid cyst recurrence, by suppressing further cyst fluid secretion (Figure 5) [13, 18]. Routine preventive measures to avoid gas embolism should be used, by limiting argon flow, by careful monitoring of the intra-abdominal pressure and by opening a trocar valve to avoid intraperitoneal over-pressurisation. The residual cystic cavity is routinely drained to avoid postoperative fluid collection. In situ omentoplasty is employed in all situations where cyst location (superiorly and posteriorly) may lead to recurrence due to coverage of the cystic cavity by adjacent organs.

Results of treatment. By strictly using these principles of managing CLCs, excellent long-term results were obtained in our experience, with no late residual or relapsing symptoms or cyst recurrence in patients suffering from simple CLCs [13]. Factors related to cyst recurrence are previous history of surgical fenestration, incomplete deroofing technique, deep-sited cysts, cyst location in the right superior (segment 8) or posterior (segment 7) areas of the liver and multilocular CLCs [8]. The technique is safe with a minimal morbidity and is associated with reduced hospital stay for the patient compared with an open (or converted) approach. The conversion rate is low and in our experience was mostly related to complicated CLCs mimicking neoplastic cysts [13]. In reported series with a follow-up period exceeding 1 year, late cyst recurrence was observed in 0–28%

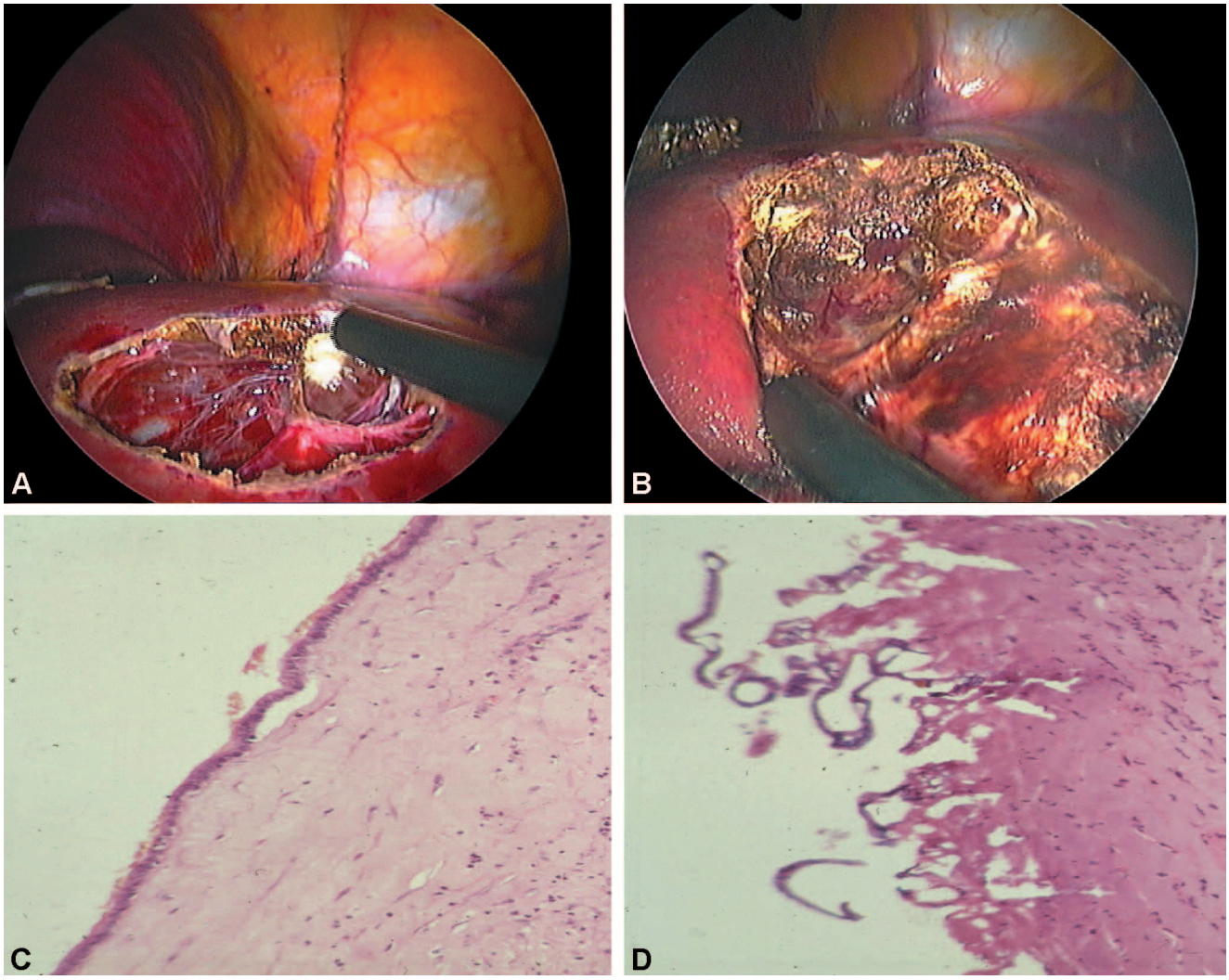

Figure 5. *Destruction of the cystic wall epithelium by vaporisation using an argon beam coagulator at the end of the deroofing procedure for a congenital liver cyst (A, B): microscopic aspect of the cystic wall epithelium before (C) and after vaporisation (D).*

Table 2. *Worldwide reported experience with laparoscopic deroofing of congenital liver cysts (CLCs) in series exceeding 10 patients*

Authors	Year	Patients	Conversion	Mortality	Complications	Reoperation (surgical or not)	Mean follow-up (months)	Late recurrence
Emmerman [23]	1995	12	0	0	17%	0	NA	8%
Morino [12]	1996	10	0	0	0	0	4-60	0%
Gigot [8]	1996	17	6%	0	15%	6%	10 (1–48)	44%
Fabiani [24]	1997	10	0	0	0	0	25.5 (6–67)	0%
Hansen [29]	1997	17	6%	0	18%	12%	30 (3–68)	6%
Martin [20]	1998	13	0	0	23%	0	25 (2–80)	8%
Heintz [4]	1998	10	10%	0	0	20%*	33 (2–43)	28%
Katkhouda [21]	1999	16	6%	0	6%	6%	30 (3–78)	0%
Payatakes [22]	1999	12	0	0	17%	8%	36 (4–84)	17%
Zalaba [25]	1999	21	0	0	0	9.5%**	12.5 (1–54)	0%
Zacherl [1]	2000	11	0	0	9%	18%*	37 (6–76)	14.3%
Andriani [26]	2000	17	0	0	12%	0	23 (3–48)	6%
Gigot [13]	2001	17	23%	0	18%	6%	38 (3–122)	6%: 0% in simple CLC
Regev [27]	2001	18	0	0	0	0	63 (6–180)	11%
Fiamingo [28]	2003	10	0	0	10%	0	34	10%
Kwon [18]	2003	14	0	0	0	0	56 (10–87)	0%

*For an erroneous diagnosis of liver cystadenoma (three patients) and hydatid liver cyst (one patient).
**For an erroneous diagnosis of liver cystadenocarcinoma (one patient) found later to be unresectable.

[1, 4, 19–22] and was 6% in our experience for the whole series during a mean follow-up of 3 years, but was 0% in simple unilocular CLCs [13]. The worldwide reported experience with laparoscopic management of CLC in series exceeding 10 patients is detailed in Table 2 [1, 4, 8, 12, 13, 19–29].

In conclusion, when adequate selection of patients and type of cystic liver disease and meticulous and aggressive surgical technique are used, the laparoscopic approach appears to be the gold standard treatment for patients suffering from CLC.

Adult polycystic liver disease

Selection of patients. Adult polycystic liver disease (APLD) is a rare condition which is difficult to treat, because highly symptomatic cystic hepatomegaly is often associated with severely impaired quality of life and with complicated clinical presentation. The purpose of any treatment option is to reduce significantly (or to replace) the mass effect of this huge polycystic hepatomegaly with a minimal morbidity in order to achieve long-term relief of symptoms and to improve the quality of the patient's life. Currently, the most appropriate therapeutic approach for APLD remains controversial between open fenestration technique [30, 31], open partial liver resection [32–34] or liver transplantation [35, 36]. Because most patients are suffering from diffuse forms of the disease – namely type II in the Morino classification [12, 37] or type II or III in our own classification (Figure 6) [31] – laparoscopic fenestration is usually unable to access and fenestrate efficiently deep-sited liver cysts, and thus to reduce the volume of polycystic hepatomegaly [8, 12, 31, 37, 38]. Despite the reported advantage of reduced peritoneal adhesions and thus facilitation of reoperative procedures in these patients [38], the laparoscopic approach should be abandoned in diffuse forms of APLD (type II and III in our classification), as suggested by several authors [12, 37, 38] and by us [8, 13, 31]. However, type I APLD, which represents a limited subgroup of selected patients (10% in our experience) [31], has already been stated by Morino *et al.* [12, 37] and by us [31] to be an indication for laparoscopic fenestration. This condition is indeed very comparable to patients with dominant CLC. In our updated experience, recurrence is also frequent is this group of patients, resulting from untreated deep-sited liver cysts, but the patients were free of symptoms and do not require further treatment so late.

Surgical technique. The laparoscopic fenestration technique used for treating CLC is also applied to APLD patients. However, difficulties in managing APLD patients laparoscopically include strong limitations for complete mobilisation of the huge cystic hepatomegaly, especially for the right liver lobe. In essence, laparoscopic access to the posterior and superior part of the liver is almost impossible in APLD patients. Secondly, during the Lin deroofing procedure, there is an increased risk of injuring small biliary and vascular radicles running within

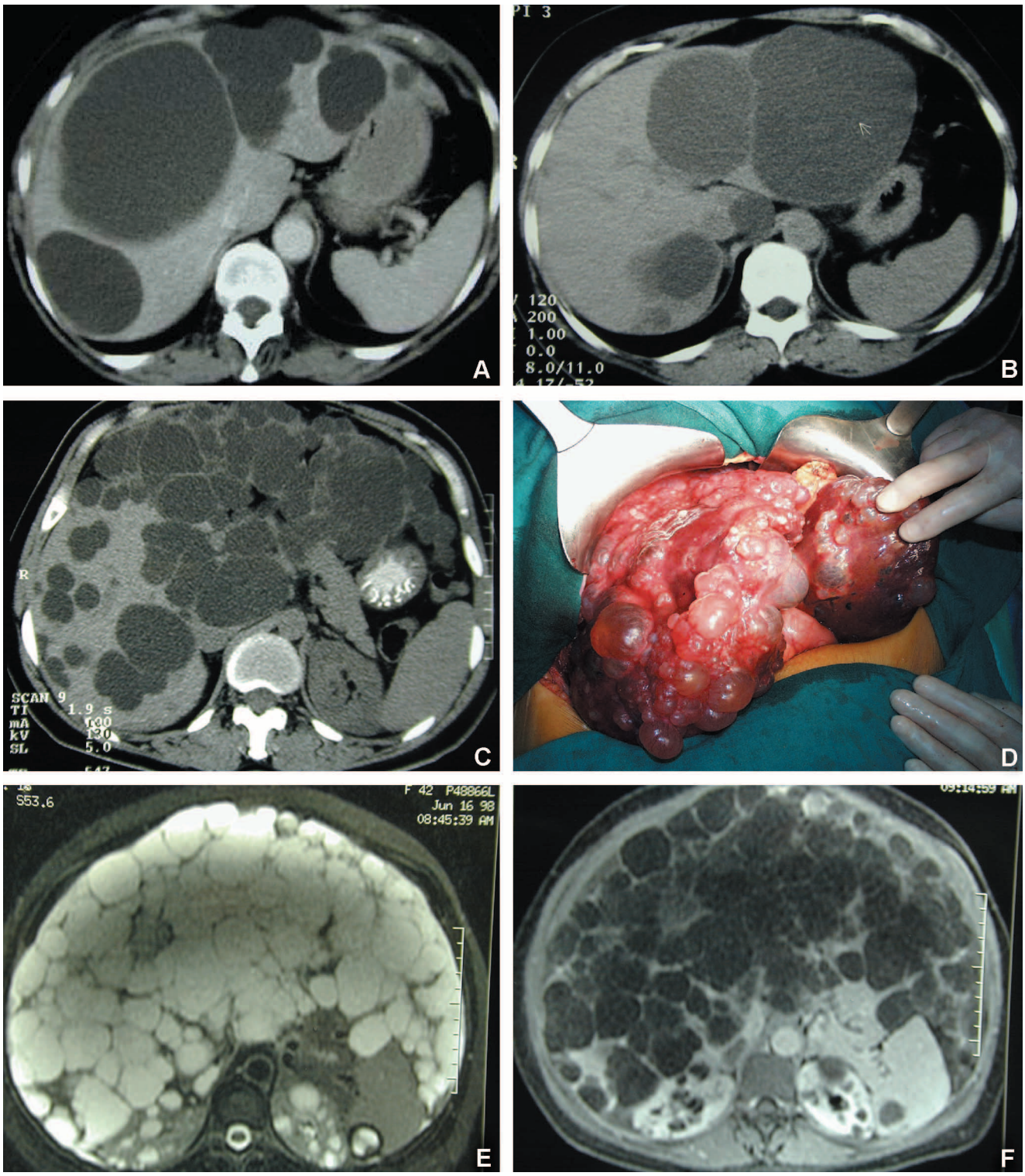

Figure 6. *Authors' classification of adult polycystic liver disease (APLD): type I APLD represents a valuable indication for laparoscopic fenestration (A, B) while type II APLD (C, D) and type III APLD (E, F) are poor indications for laparoscopic management.*

cystic walls, especially during interseptal fenestration when accessing deep liver cysts.

Results of treatment. The worldwide reported experience with laparoscopic management of APLD is detailed in Table 3 [8, 12, 13, 20, 21, 28, 37–43], in which late recurrence corresponds with late postoperative persis-

Table 3. *Worldwide reported experience with laparoscopic management of adult polycystic liver disease (APLD)*

Authors	Year	Patients	Type of APLD	Type of lap. procedure	Conversion rate	Death	Complications	Early reoperation (surgical or not)	Mean follow-up (months)	Late recurrence
Mazziotti [39]	1992	2	I	Deroofing	0	N	0	N	6	0%
Morino [37]	1994	2	I	Deroofing	0	N	100%	N	6	0%
		5	II	Deroofing	40%	N	40%	N	6	80%
Jeng [40]	1995	1	I	Deroofing + alcohol	0	N	N	N	18	0%
Gigot [8]	1996	9	I	Deroofing	11%	N	11%	N	7 (1–17)	22%
Morino [12]	1996	6	I	Deroofing	0	N	33%	N	34 (4–57)	17%
		7	II	Deroofing	29%	N	29%	N		57%
Kabbej [38]	1996	5	I	Deroofing	0	N	54%	N	31 (9–49)	60%
		8	II	Deroofing	0	N		N		89%
Martin [40]	1998	7	NA	Deroofing	0	N	29%	N	37 (1–67)	71%
De Simone [41]	1998	1	I	Deroofing	0	N	0	N	18	0%
Katkhouda [21]	1999	9	I	Deroofing	11%	N	33%	N	30 (3–78)	11%
Descottes [42]	2000	4	I	Deroofing	0	N	0	N	NA	75%
Gigot [13]	2001	2	I	Deroofing	0	N	0	N	99 (54–144)	100%
Fiamingo [28]	2003	6	I and II	Deroofing	0	N	50%	N	34 (2–72)	33%
Descottes [43]	2003	2	I	lap. LLS	0	N	0	N	12	0%

NA, data not available; lap., laparoscopic; LLS, left lateral segmentectomy.

tence or recurrence of symptoms and/or to late reoperation for primary treatment failure. It could be observed that results are very disappointing in APLD type II, with a late recurrence rate between 57% and 89%. In contrast, the late recurrence rate was lower in type I APLD, but with a wide range of success. Due to the minimally invasive nature of the procedure, laparoscopic fenestration may thus remain a disputable option for palliative treatment in the rare and very selected group of highly symptomatic type I APLD patients with large, symptomatic liver cysts located in the anterior surface of the liver. However, late recurrence should be assessed carefully. On the other hand, in diffuse forms of APLD, laparoscopic fenestration appears to confer little or no benefit.

Liver cystadenoma

Liver cystadenoma is a rare cystic neoplasm, characterised by a certain tendency to malignant transformation to cystadenocarcinoma. Typical features of liver cystadenoma on imaging techniques include smooth-walled low-density cysts with the presence of thick, irregular cyst walls, heterogeneous (mucoid) intracystic fluid and thin hypervascular internal septations [44–48]. Again, it should be emphasised that accurate preoperative differential diagnosis is crucial, to avoid inadequate surgical treatment. Indeed, because this lesion may be malignant, cyst fenestration or drainage procedures are contraindicated. Zalaba *et al.* [25] even reported an erroneous laparoscopic fenestration procedure in a 17-year-old patient suffering from liver cystadenocarcinoma, requiring reoperation later but found to be unresectable at this time. Complete excision of the lesion is thus the only successful mode of therapy in order to cure the patient, by reducing the possibility of progressive symptomatic enlargement, of secondary infection and of possible malignant transformation. Several observations of confusion between neoplastic cysts and CLCs have already been reported, with previous attempts at surgical drainage procedures before definitive resection in many series [27] or with adequate detection only at final pathological examination [4, 49, 50] or with postoperative recurrence during follow-up examination following laparoscopic fenestration procedures, leading to tumour recurrence and further reoperation to perform radical excision [1, 25]. Most cystic lesions that mimic cystic neoplasms are CLCs complicated by haemorrhage or infection [5, 13, 51], To the best of our knowledge, few observations of laparoscopic resection of LCA have been reported [43, 52]. Our personal experience includes one young male patient submitted to successful laparoscopic left hepatectomy for a benign form of LCA (Figure 7). The postoperative course was simple and the patient remains alive and disease-free 27 months postoperatively.

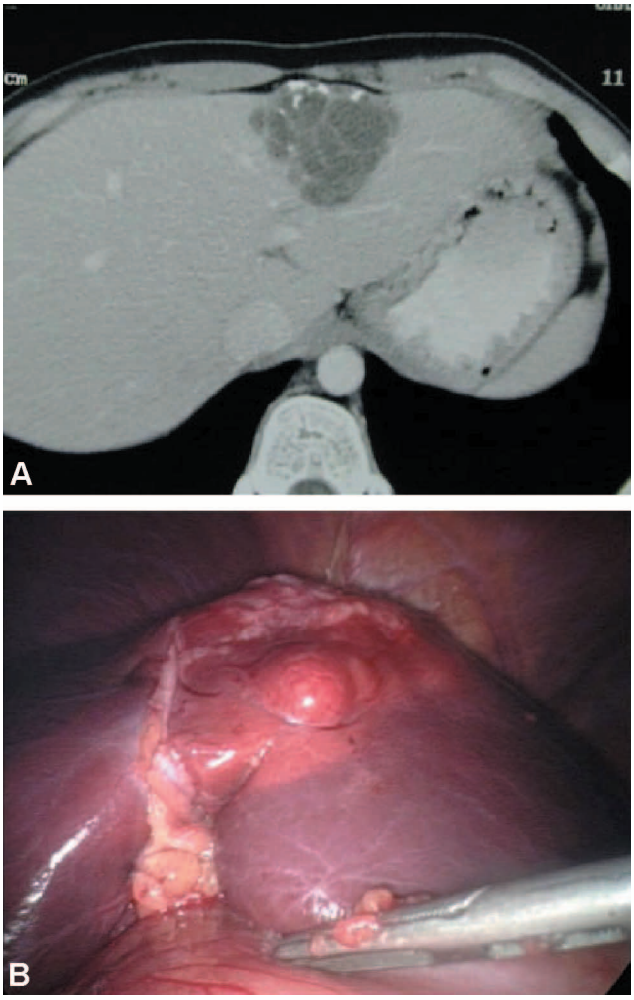

Figure 7. *Laparoscopic liver resection for a liver cystadenoma. (A) Preoperative computed tomography; (B) intraoperative view before resection.*

In conclusion, open hepatic resection remains the mainstay of surgical therapy for neoplastic liver cysts, but in selected cases of lesion appropriately located within the liver, a laparoscopic approach can be selected.

Benign hepatocellular tumours

Selection of patients

The management of hepatocellular tumors has benefited from a clearer pathological classification [53], a better understanding of the natural history of each tumour type and recent improvements in modern imaging techniques. Thus, the indications for surgical resection of benign liver tumours have been progressively restricted and tailored according to each type of liver tumour. Liver haemangioma and focal nodular hyperplasia (FNH) are considered as benign and indolent disease with no risk of malignant transformation or complicated clinical presentation during natural history [54, 55]. Despite a large representation of these tumours in the reported laparoscopic series of liver resection of hepatocellular tumors (see Table 5), these lesions should not be resected – even by laparoscopy – unless they are responsible for specific disease-related symptoms such as pain or compression due to large strategically situated lesions or in case of enlarging tumour. Accordingly, small and superficial tumours, even if located in easily accessible liver segments – which represent the best indication for laparoscopic liver resection (LLR) – do not represent an indication for surgical resection, except in case of atypical appearance with a diagnostic ambivalence on preoperative radiological investigations. However, this feature is uncommon because the sensitivity of imaging studies to diagnose these diseases correctly is high, being over 90% for liver haemangioma [56, 57] and around 70–90% for FNH [58, 59]. In case of dubious diagnosis at radiological work-up, Cherqui *et al.* [58] have emphasised the role of laparoscopically guided biopsy to improve diagnostic accuracy before going to laparoscopic resection. On the contrary, liver cell adenoma (LCA) should be resected anyway, irrespective of the presence of symptoms, or the tumour size and location [55, 58]. Indeed, indication for resection of this lesion is based on a natural history with bleeding tendency, on the rare but well documented risk of malignant transformation and on the sometimes difficult differentiation on imaging studies between LCA and well-differentiated hepatocellular carcinoma. Thus, we would like to emphasise the need to retain the general philosophy of restricting surgical indications in benign liver tumours, even with the development of minimally invasive surgery.

Finally, as for cystic liver diseases, an adequate selection of patients and liver tumours is a key factor for success of LLR. In other words, not all benign liver tumours are amenable to LLR. The best indications are small, superficial, peripheral lesions, located in the left lateral segments (segments II and III) or in the anterior segments of the right part of the liver, i.e. the anterior part of segment IV, segment V and segment VI, those being described as 'laparoscopic segments'. Large tumours, tumours close to the hepatic veins or the cavo-hepatic junction, centrally or posteriorly located tumours in the right part of the liver are not ideal candidates for

Table 4. *Comparison between the worldwide reported literature experience and the European multicentre series concerning laparoscopic liver resections for benign liver tumours*

Parameter	Worldwide reported literature [42, 52, 61–95]	European multicentre series [43]
Patients	180	87 (88 resections)
Indications	out of 173 patients	out of 87 patients
• Haemangioma	39 (22.5%)	13 (15%)
• Focal nodular hyperplasia	74 (43%)	48 (55%)
• Liver cell adenoma	30 (17.3%)	17 (20%)
• Hamartoma	0	3 (3.5%)
• Cystadenoma	1 (0.8%)	1 (1.1%)
• Recurrent pyogenic cholangitis	7 (4%)	0
• Congenital liver cyst	6 (3.5%)	0
• Adult polycystic liver disease	2 (1.1%)	2 (2.3%)
• Hydatid liver cyst	7 (4%)	3 (3.5%)
• Others	7 (4%)	0
Hepatic segmental location	out of 141 patients	out of 87 patients
• Laparoscopic segments (S2–S6)	96.5%	94%
• S1, S7 or S8	3.5%	6%
Type of liver resections	out of 154 patients	out of 87 patients
• Wedge	82 (53%)	38 (43.2%)
• Segmentectomy	16 (10%)	25 (28.4%)
• Bi-segmentectomy S5-S6	3 (2%)	1 (1%)
• Left lateral segmentectomy :	52 (34%)	20 (23%)
• Major hepatectomy :	1 (1%)	4 (4.5%)
Conversion	out of 180 patients 3.3%	out of 87 patients 10%
Mortality rate	out of 160 patients 0	out of 87 patients 0
Complications rate	out of 160 patients 9%	out of 87 patients 5%
Reoperation rate	out of 160 patients 2%	out of 87 patients 1%

laparoscopic resection. However, large lesions are easily resectable laparoscopically when located in the left lateral segments. Tumour location within these 'laparoscopic segments' (segments II to VI) are reported in 96.5% and 94% of the worldwide literature [42, 52, 61–95] and the multicentre European series [43], respectively (Table 4). However, the use of a hand-assisted technique was recently reported to facilitate safe access to the posterior and superior part of the right liver [94]. When taking into consideration the restrictive philosophy of surgery in benign liver tumours and the need for such adequate selection of patients, the role of laparoscopic surgery was reported to represent 2% [96] to 10% [88] of the recruitment of patients referred to expert HPB centres. It was 8% in our own experience, but was described to be as high as 19% [84] and 20% [97], depending on patient selection.

Surgical technique

The vast majority of LLR reported in the literature are

Table 5. *Worldwide reported experience with laparoscopic resection of benign liver tumours in series exceeding 10 patients*

Authors	Year	Patients	Conversion	Mortality	Complications	Reoperation (surgical or not)	Mean POHS (days)	Mean follow-up (months)	Late recurrence
Rau [79]	1998	15	1 (6.7%)	0	1 (6.7%)	0	7.8	NA	NA
Katkhouda [81]	1999	11	1 (9%)	0	0	0	4.7	30	0%
Descottes [42]	2000	13	0	0	0	0	4.3	NA	NA
Cherqui [84]	2000	18	2 (11%)	0	1 (5.5%)	1 (5.5%)	5.2	NA	0%
Farges [88]	2002	21	0	0	2 (9.5%)	1 (5%)	5.1	NA	NA
Lesurtel [92]	2003	11	1 (9%)	0	0	0	8	NA	NA
Descottes [43]	2003	87	9 (10%)	0	4 (5%)	1 (1.1%)	5	13	0% (except 2 APLD)

minor resections, limited to wedge resections or to removal of one or two liver segments. Left lateral segmentectomy is the anatomical liver resection that is most easily reproducible laparoscopically. Very few major hepatectomies were done laparoscopically, most of them being then performed through the hand-assisted approach [42, 43, 73, 84, 98]. The reasons for this obvious process of selection include the difficulty of achieving laparoscopically complete mobilisation of the liver, safe exposure and control of the suprahepatic junction, easy and safe intraparenchymal control of major vascular trunks, 3-D determination of the transection line's orientation, control of severe peroperative bleeding and application of total vascular isolation technique. Thus to date, until more data are available from expert centres, the legitimacy of laparoscopic major hepatectomies in usually young patients suffering from benign liver tumours remains questionable.

Laparoscopic hepatectomy is a technically demanding operation, requiring complex and expensive equipment and instrumentation. Specific requirements include harmonic shears and ultrasonic dissector for liver parenchymal transection, endo-stapler with vascular cartridges for controlling major vessels and argon beam coagulator for haemostasis of the transection line. Laparoscopic ultrasound is useful to locate the tumour when not apparent at the liver surface, to determine the tumour relationship with adjacent major vascular and biliary structures and to help in mapping the resection line on the liver surface, in the absence of determination by manual palpation during a totally laparoscopic approach. Gas embolism is a specific potential risk of LLR, but has never been reported outside the (over)use of the argon beam coagulator [52, 99]. Great care must be applied when using the argon beam coagulator laparoscopically, with preventive measures including limitation of the argon flow (at 3 litres per minute, 50–70 W), careful monitoring of the intra-abdominal pressure and opening of a trocar valve to avoid over-pressurisation. Major bleeding is also a well-known concern during liver resection and is more difficult to control laparoscopically, being responsible for half of the conversions in the multicentre European series [43]. For this reason, the Pringle maneuver has been used quite often during LLR – in 67% of the patients in the series reported by Cherqui *et al.* [84] – even for hepatectomies limited to one or two segments, a need which is not encountered for such minor resections when they are performed by an open approach. Portal triad clamping is obtained by encircling the porta hepatis with a sling used as a tourniquet or by using a laparoscopic vascular clamp. Several clinical series have demonstrated the safety and the tolerance of the Pringle manoeuvre when performed laparoscopically [84, 88, 92, 98, 100] However, this manoeuvre does not seem to be necessary any longer with experience gained for such minor hepatectomies. Again, a hand-assisted technique is able to facilitate the exposure and control of major vessels during parenchymal hepatic transection. Biliary leaks, another complication of liver resections, should be prevented by precise intrahepatic dissection and clipping, but were sometimes encountered with the use of harmonic shears in our experience. Finally, as for other laparoscopic procedures, it should be highlighted that conversion to an open procedure should not be considered a failure but rather as a good surgical judgement to maintain the safety of the procedure.

Results of treatment

In 1992, Gagner *et al.* [65] performed the first non-anatomical resection of a FNH. But the first true anatomical liver resection, namely a left lateral segmentectomy, was reported in 1996 by Azagra *et al.* [72] for a LCA. Since that time, an increasing number of papers have been published concerning laparoscopic resection of benign hepatocellular tumours, most of them being case reports or small series of patients. To date, a total of 180 patients was collected from the worldwide literature and compared to 87 patients from a European multicentre series [42, 52, 61–95] (Table 4). Finally, Table 5 gives details of the reported series exceeding 10 patients [42, 43, 79, 81, 84, 88, 92]; successful laparoscopic performance of LR was achieved in 90–97%. Conversion to an open approach (3–10%) is related mainly to bleeding, but also to tumour relationship with major vascular trunks, poor tumour location, risk of HLC rupture and technical problems [43]. No mortality was reported to date for LLR of benign liver diseases and the complication rate is low, between 5% and 9%. Early postoperative reoperation was required in 1–2%. Thus, in expert hands in hepatic surgery and advanced laparoscopic procedures, the technique appears to be fairly safe. Postoperative recovery appears to be good, with many series reporting postoperative hospital stay <5 days [42, 43, 61–71, 76–78, 81, 83, 84, 88, 90, 91, 93, 94]. These results compare

Table 6. *Comparative reported series of laparoscopic and open liver resections for benign and malignant liver tumours*

	Rau (1998) [79]		Shimada (2001) [103]		Farges (2002) [88]		Mala (2002) [97]		Lesurtel (2003) [92]		Morino (2004) [104]	
Features	**lap**	**open**	**lap**	**open**	**lap**	**open**	**lap**	**open**	**lap**	**open**	**lap**	**open**
Study	Matched		Retrospective		Matched		Retrospective		Matched		Matched	
Patients	17	17	17	38	21	21	13	14	18	20	30	30
Age	48	47	62	63	38	39	68	59	55	47	56	58
Benign/malignant	15/2	15/2	HCC	HCC	21/0	21/0	CRLM	CRLM	12/6	13/7	16/14	5/25
Chronic liver disease	0	0	76.5%	73.7%	0	0	0	0	28%	30%	10%	30%
Tumour size (mm)	NA	NA	26	25	49	NA	26	30	46	53	42	41
Liver segments S2–S6	100%	100%	100%	100%	90%	90%	84%	71%	S2-S3	S2-S3	100%	100%
Minor liver resection	100%	100%	100%	100%	100%	100%	100%	100%	LLS	LLS	100%	100%
Transfusion rate	6%	17%	5.9%	10.5%	5%	NA	1	1.5	0	15%	13%	6.6%
Operative time (min)	183	128 *	325	280	177	156	187	185	202	145**	148	142
Vascular clamping	–	–	–	–	57%	NA	0	21%	56%	40%	13%	53%*
Conversion rate	6%	–	0	–	0	–	0	–	11%	–	0	–
SM invaded	0	NA	NA	NA	–	–	5%	12%	0	0	0	4%
SM < 1 cm	0	NA	41%	50%	–	–	19%	23%	6%	0%	43%	40%
Opioids need	?	?	NA	NA	16	32*	1	5***	NA	NA	NA	NA
Mortality	0	0	0	0	0	0	0	0	0	0	0	0
Complications	6%	6%	5.9%	10.5%	10%	10%	13%	26%	11%	15%	6.6%	6.6%
POHS (days)	7.8	11.6*	12	22***	5	6.5***	4	8.5***	8	10	6.4	8.7*
Follow-up (months)	NA	NA	17	28	NA	NA	8	16	NA	NA	NA	NA
Late disease death	NA	NA	NS	NS	–	–	15%	21%	NA	NA	NA	NA
Port site metastases	NA	NA	0	NA	–	–	NA	NA	NA	NA	NA	NA

NA, data not available (data are expressed as medians); HCC, hepatocellular carcinoma; CRLM, colorectal liver metastases; LLS, left lateral segmentectomy; lap, laparoscopic.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

favourably with those for similar open hepatectomies, this latter approach having achieved to date a significant reduction in postoperative morbidity and hospital stay, especially for minor liver resections [101, 102].

A few series comparing laparoscopic with open minor hepatic resections for benign and malignant liver diseases have been reported to date (Table 6) [79, 88, 92, 97, 103, 104]. Only four of these studies compared matched patients [79, 88, 92, 104]. The laparoscopic group was demonstrated to be associated with a similar complications rate [79, 88, 92, 97, 103, 104], a longer operative time (at least during the learning curve of the laparoscopic group) [79, 92], a longer portal triad clamping time [92, 104], a decreased blood loss [92] and with the usual postoperative functional benefits of minimally invasive surgery, such as a reduction of postoperative morphine administration [88, 97] and hospital stay [79, 88, 97, 103, 104]. Despite cosmetic results not being a criterion of evaluation in liver surgery, a significant benefit of laparoscopic approach for liver resection is the avoidance of a large, disabling subcostal incision, responsible for early and late complications and inconvenience (pain, infection, dehiscence, muscular relaxation, sensitive defect, etc.). Thus, in contrast to the management of malignant liver tumours, for which the role of LLR remains controversial [105], the laparoscopic approach is an attractive alternative to open surgery for treating benign liver tumours.

In conclusion, with strict compliance with the classic indications for surgery and for selected tumours in an appropriate hepatic location (left lateral segments or anterior segments of the right liver), laparoscopy appears to be the ideal primary approach for resecting benign liver tumours, the open approach being reserved for failure of LLR. Indeed, when performed by surgeons experienced in open liver surgery and advanced laparoscopic techniques and in a suitable technical environment, the technique appears to be safe with a low morbidity and a short postoperative hospital stay, achieving the excellence required for treating patients suffering from benign conditions.

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